REMARKS

The Office Action mailed on May 13, 2003, has been reviewed and the comments of the Patent and Trademark Office have been considered. Prior to this paper, claims 1-20 were pending in the present application. By this paper, Applicants add claims 21-28. Therefore, claims 1-28 are now pending in the present application.

Applicants respectfully submit that the present application is in condition for allowance for the reasons that follow.

Rejections Under 35 U.S.C. § 102

Claims 1-20 stand rejected under 35 U.S.C. §102(e) as being anticipated by Maeda (USP 6,556,290). In response, Applicants antedate the reference.

Applicants note that they have previously filed a certified copy of the foreign application from which the present application claims the priority date of August 28, 2000. Applicants further submit herewith, under a separate letter, an English language translation together with a statement that the translation of the certified copy is accurate per 37 C.F.R. § 1.55 (a)(4).

Because the priority date of the present application is before the filing date of Maeda (March 05, 2001), the contents of Maeda are not a statutory bar to the present invention, and, therefore, allowance of the claims is respectfully requested.

Specification Objections

The abstract of the disclosure was objected to because of the use of the phrase the "present invention relates to." Applicants submit a new abstract, and respectfully request reconsideration.

The disclosure of the specification was objected to due to reference to the claims of the application. Applicants have amended the specification, as seen above, and respectfully request reconsideration.

Drawing Objections

The drawings were objected to as failing to show every feature of the invention specified in the claims. In response, Applicants have added Figs. 2-11, which utilize labeled representations for some of the elements of the present invention. Applicants submit that support for the drawings can be found in the specification and claims, as filed, and thus no new matter has been added.

Applicants rely on 37 C.F.R. §1.83(a), which states that "conventional features disclosed in the description and claims, where their detailed illustration is not essential for a proper understanding of the invention, should be illustrated in the drawing in the form of a graphical drawing symbol or a labeled representation (e.g., a labeled rectangular box.)"

Regarding the alleged feature of "the phase angle," Applicants respectfully submit that this does not have to be shown in the drawings, as this is akin to showing, for example, time, temperature, weight, etc.

Applicants respectfully request reconsideration of the drawings in view of the above drawing amendments and comments.

Claim Objections

In the Office Action, claims 5 and 17 were objected to for various informalities. Applicants have amended claims 5 and 17, and respectfully request reconsideration.

Rejections Under 35 U.S.C. § 112, First Paragraph

The claims stand rejected under 35 U.S.C. §112, first paragraph, as failing to comply with the enablement requirement. Specifically, the Office Action states that the "specification . . . does not teach how (Claim 1) the 'phase angle of the light field is varied by a modulation means in such a way that interference phenomena do not occur in the optical beam path, or occur only to an undetectable extent, within a predeterminable time interval.'"

As is explained on the first full paragraph of page 2, a high coherence length, which is inversely related to the line width (see page 1, line 20), "is a problem since it can lead to the formation of undesired interference phenomena in the optical beam path." That is, a narrower line width of a laser results in a longer coherence length, and thus a narrower line width results in a high interference effect.

Applicants respectfully submit that the specification, in particular, the "Summary of the Invention" section, does indeed enable one of ordinary skill to practice claim 1 and the claims that depend from claim 1. As seen above, Applicants have amended the specification so that the teachings of the "Summary of the Invention" section now are located in the "Detailed Description of the Invention" section, and thus, any requirement that the enabling teachings be located in this section is now satisfied.

Regarding the teachings of the former "Summary of the Invention" section, Applicants point to lines 12-20 of page 3 of the application, where it is stated that "the EOM can *vary the phase angle of the light field in such a way that broadening of the spectral linewidth of the laser radiation is thereby achieved*" and that "a noise signal, a periodic signal or a stochastic signal could be applied to the EOM, so that spectral components are superimposed on the laser light and so that the linewidth of the laser radiation is increased to the linewidth of the superimposed signal." (Emphasis added.) Thus, by varying the phase angle, an increase in the linewidth is achieved and the coherence length is reduced, and, therefore, the interference effect is reduced.

Applicants further point to lines 21 of page 3 to line 10 of page 4 of the application, which state that:

> In a second variant, a mirror, a lens or a beam splitter is used as the modulation means. This modulation means is also arranged downstream of the laser light source. It is mounted in such a way that it also vibrates or oscillates as a result of vibrations or oscillations of the optical structure or of the casing. In the simplest case, this could involve a lens which is merely placed, but not fixed, in a lens frame. The slight vibrations or oscillations of the device, which are in any case induced, for example, by fans, cause the lens itself to oscillate. The mirror, the lens or the beam splitter could also be moved with the aid of a control element. The control element could, for example, be a piezo element to which a corresponding control signal is applied.
>
> As a result of the oscillation, vibration and/or movement of the modulation means, the optical path of the light radiation can be stochastically varied, i.e. the length of the optical path is thereby stochastically varied. Owing to the stochastic variation of the optical path, interference phenomena which may occur in the predetermined time interval are also modified, so that an integral detector--a detector which, for example, records the cumulative sum of the light intensity within the predetermined time interval--does not detect the interference phenomenon per se, and accordingly the measurement result is also not disruptively influenced.

Applicants respectfully submit that one of ordinary skill in the art would be enabled by at least the above identified teachings of the specification. Still further, Applicants submit that enabling teachings can be found, among other places, at the second and third full paragraphs of page 4 and the last full paragraph on page 5.

Also, Applicants submit a copy of an excerpt from the book "Optics" by Hecht and Zajac (See Appendix B), as further evidence that once the ordinary artisan is furnished with the teachings of the present application, he or she would be enabled to practice the present invention.

Conclusion

Applicants believe that the present application is now in condition for allowance. Favorable reconsideration of the application as amended is respectfully requested.

The Commissioner is hereby authorized to charge any additional fees which may be required regarding this application under 37 C.F.R. §§ 1.16-1.17, or credit any overpayment, to Deposit Account No. 19-0741. Should no proper payment be enclosed herewith, as by a check being in the wrong amount, unsigned, post-dated, otherwise improper or informal or even entirely missing, the Commissioner is authorized to charge the unpaid amount to Deposit Account No. 19-0741. If any extensions of time are needed for timely acceptance of papers submitted herewith, Applicant hereby petitions for such extension under 37 C.F.R. §1.136 and authorizes payment of any such extensions fees to Deposit Account No. 19-0741.

Examiner Fuller is invited to contact the undersigned by telephone if it is felt that a telephone interview would advance the prosecution of the present application.

Respectfully submitted,

Date September 15, 2003

By ______________________

Martin J. Cosenza
Attorney for Applicant
Registration No. 48,892

FOLEY & LARDNER
Washington Harbour
3000 K Street, N.W., Suite 500
Washington, D.C. 20007-5143
Telephone: (202) 295-4747
Facsimile: (202) 672-5399

Amendments to the Drawings:

Please replace the Fig. with the attached Fig. 1 in Appendix A to add element names to the Fig.. Please add the 10 new sheets (Figs. 2-11) of drawings found in Appendix A which show additional features claimed in the present application to address the objection to the drawings in the Outstanding Office Action.

APPENDIX A

Replacement Sheet
Rafael STORZ et al.
09/939,726
Atty Dkt. 016790/0432

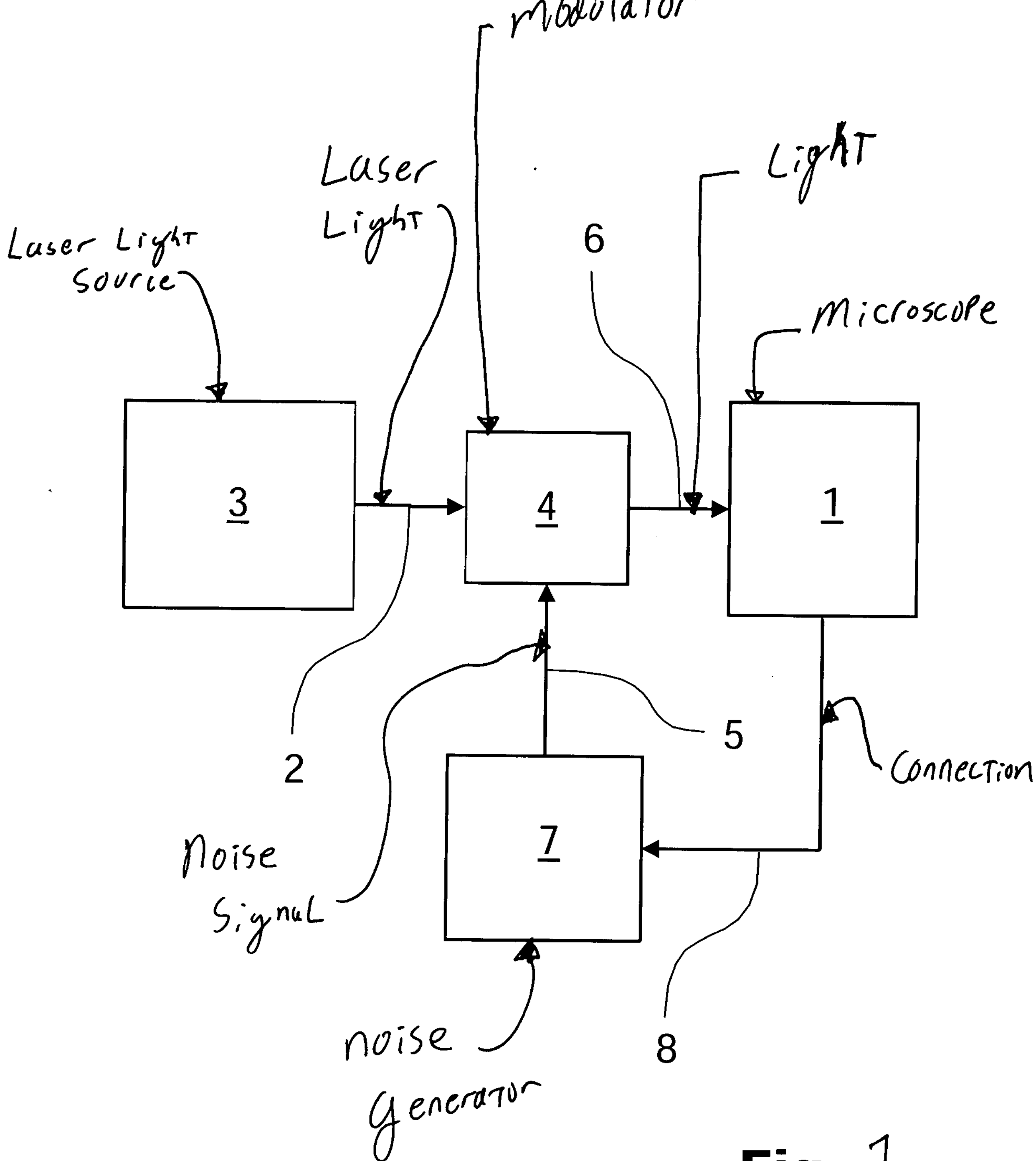

Fig. 1

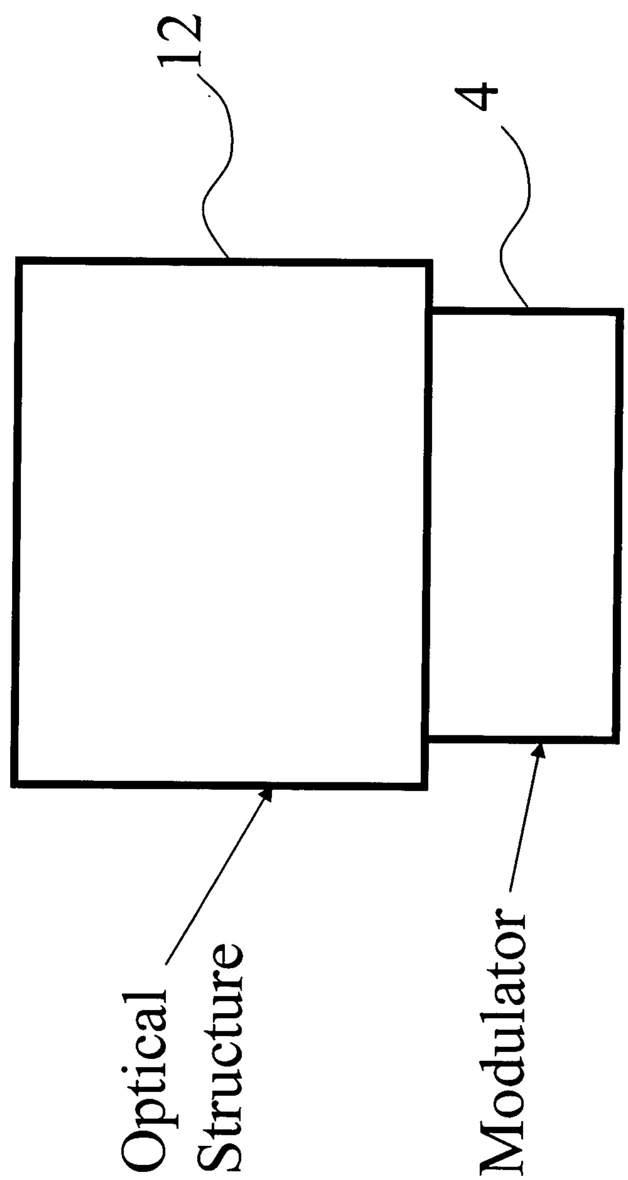

FIG. 2

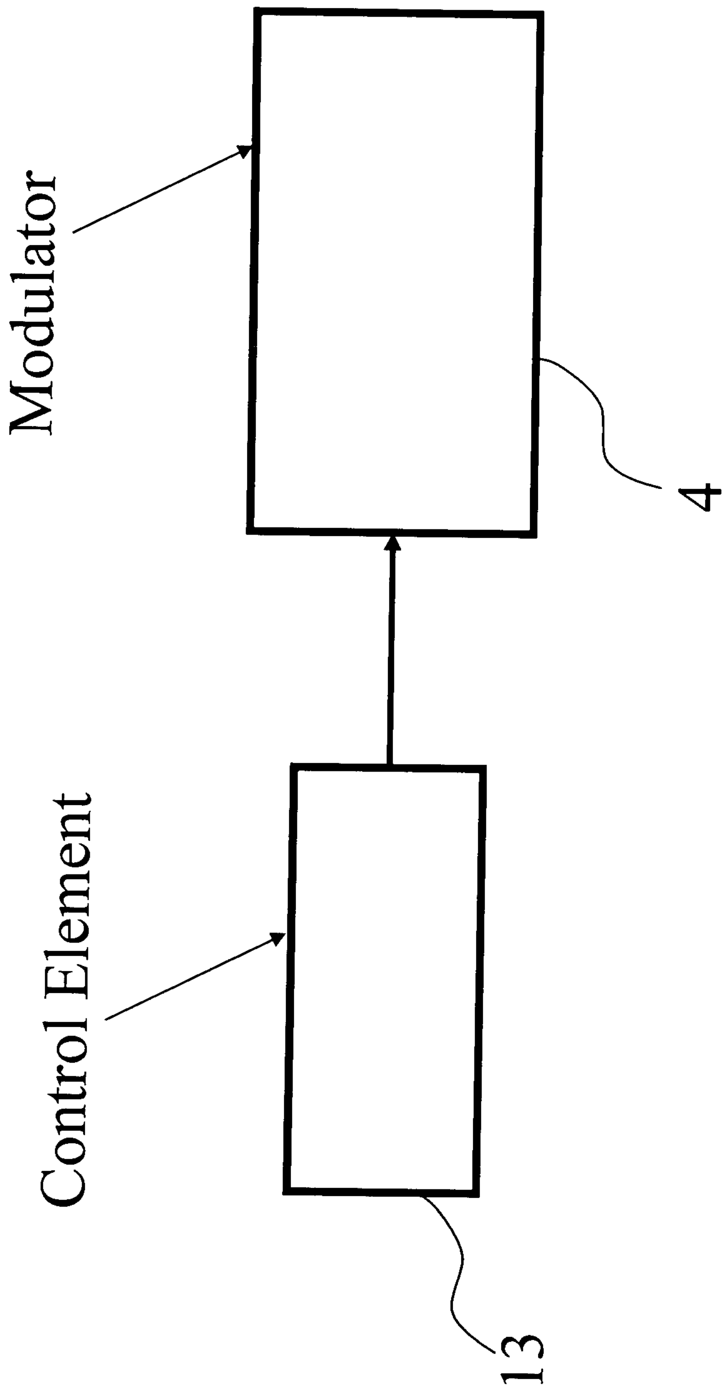

FIG. 3

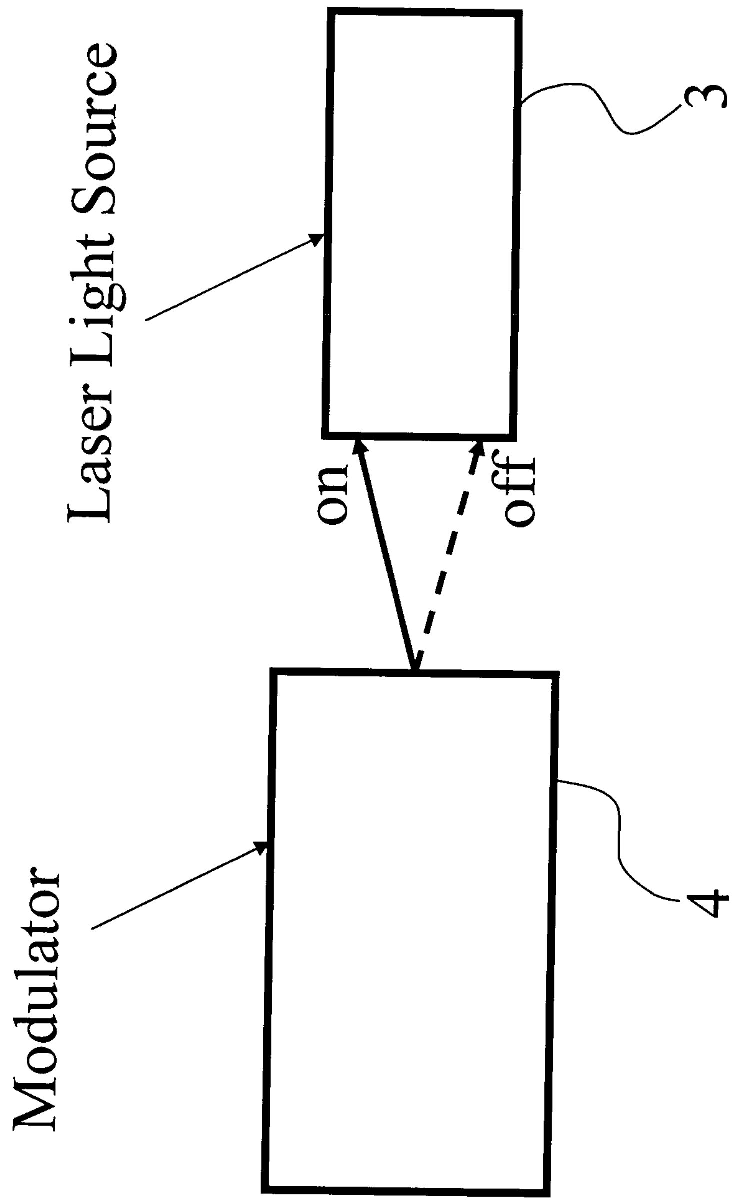

FIG. 4

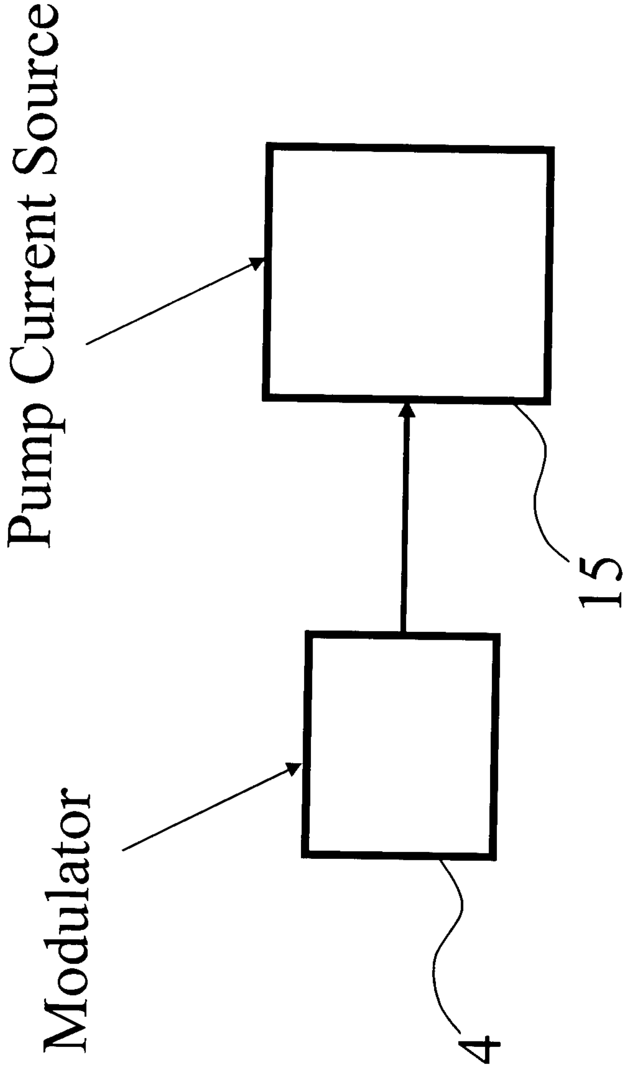

FIG. 5

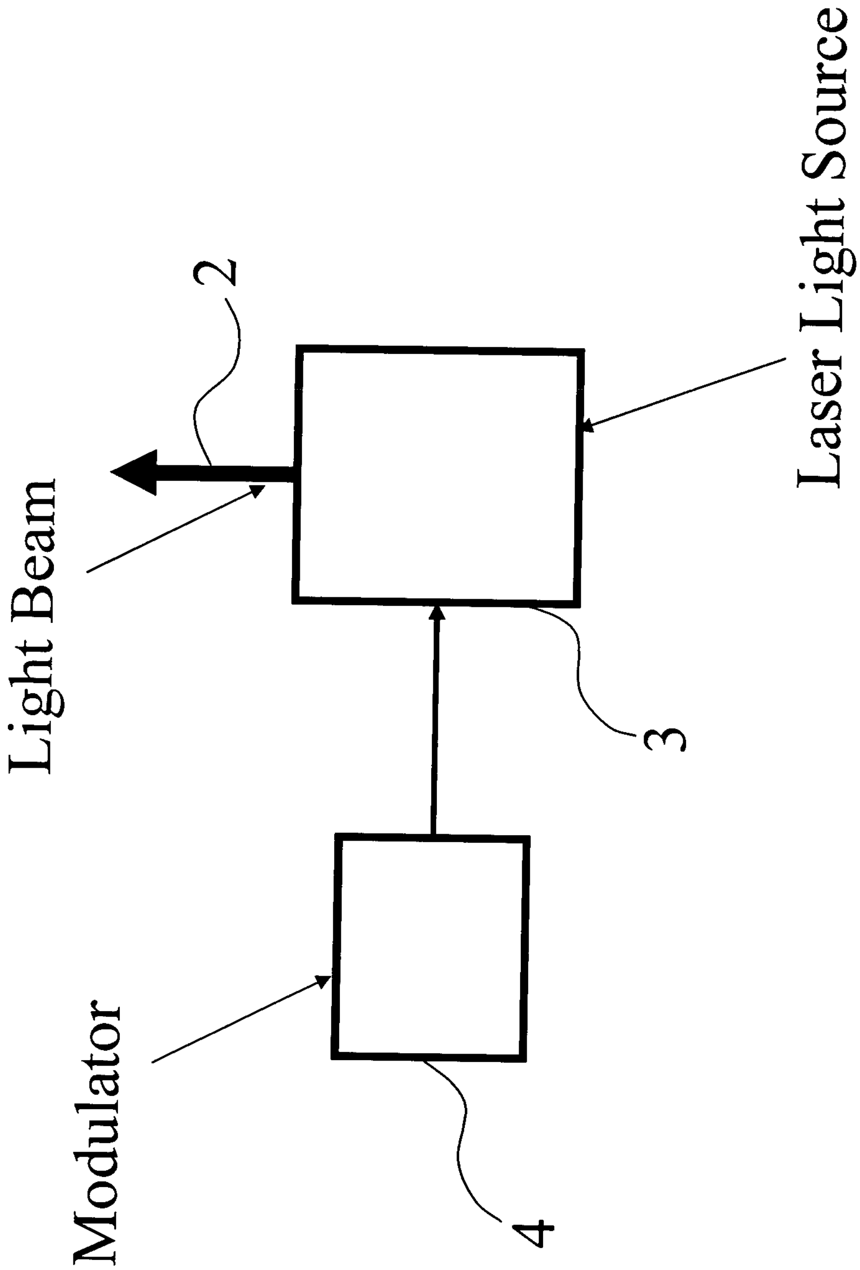

FIG. 6

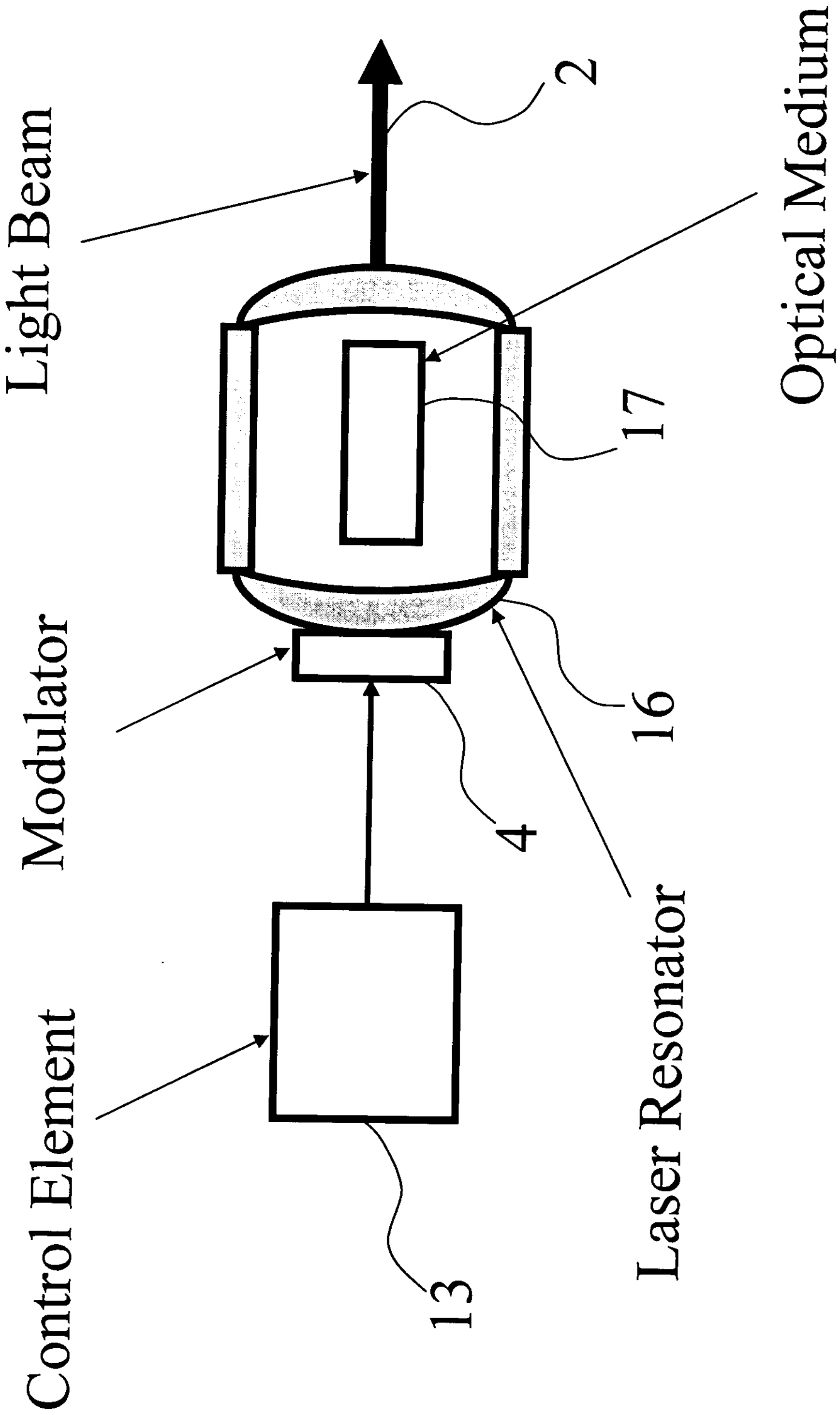
Light Beam
2
Optical Medium
17
Modulator
16
4
Laser Resonator
Control Element
13

FIG. 7

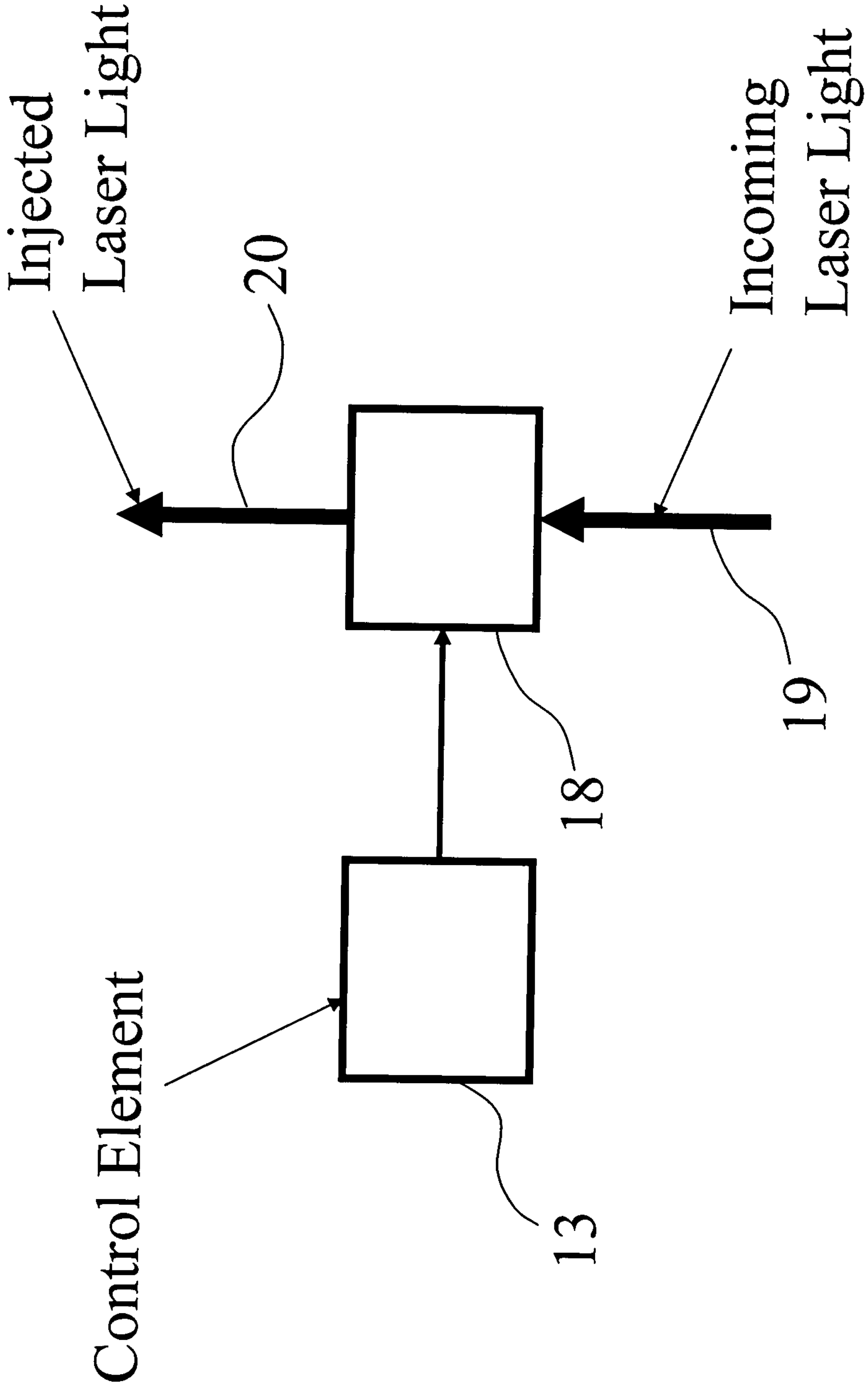
Injected Laser Light
20
Incoming Laser Light
19
18
13
Control Element

FIG. 9

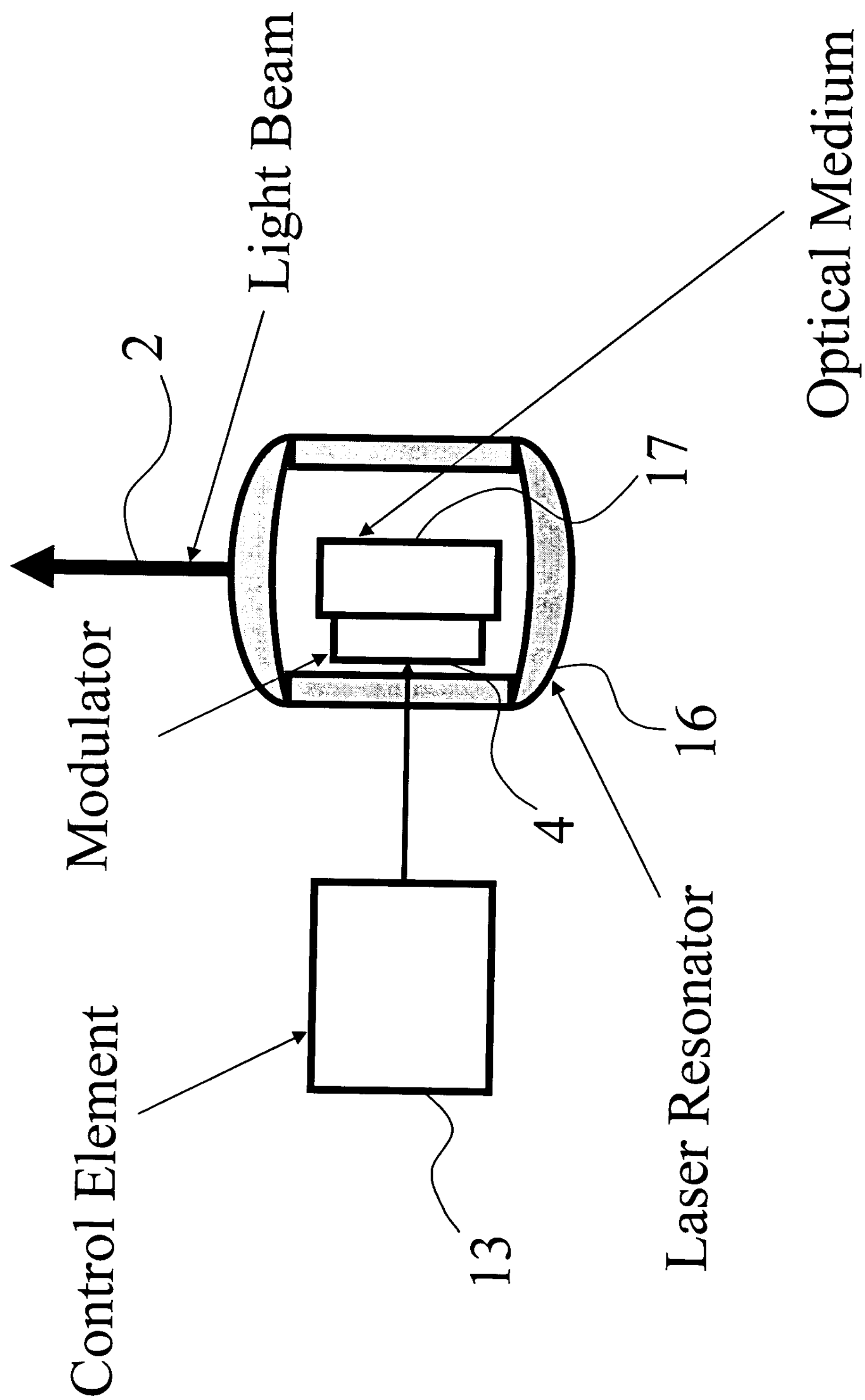
Light Beam
2
Optical Medium
17
Modulator
16
4
Control Element
13
Laser Resonator

FIG. 8

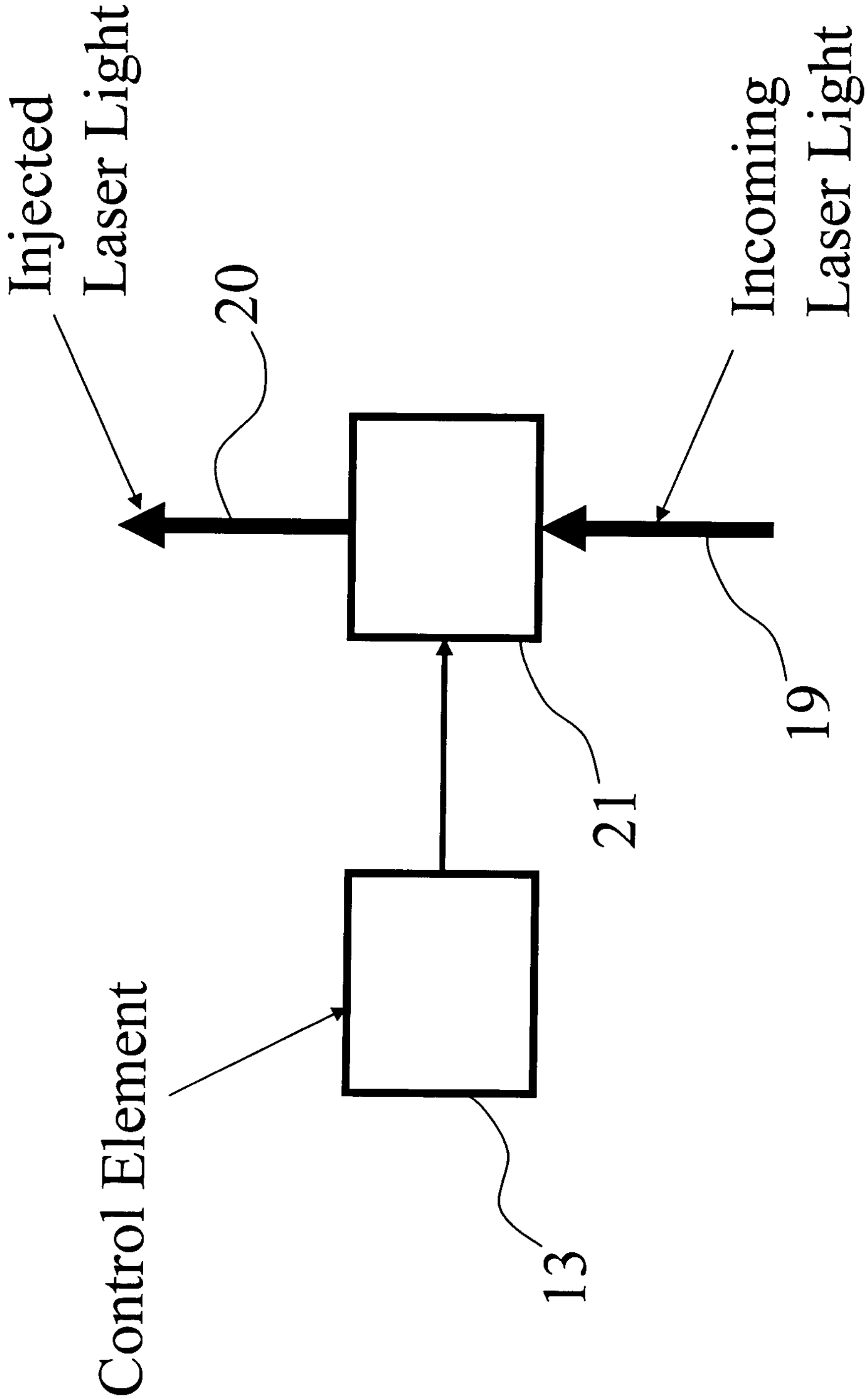
Injected Laser Light
20
Incoming Laser Light
19
21
Control Element
13

FIG. 10

Rafael STORZ et al.
09/939,726
Atty Dkt. 016790/0432

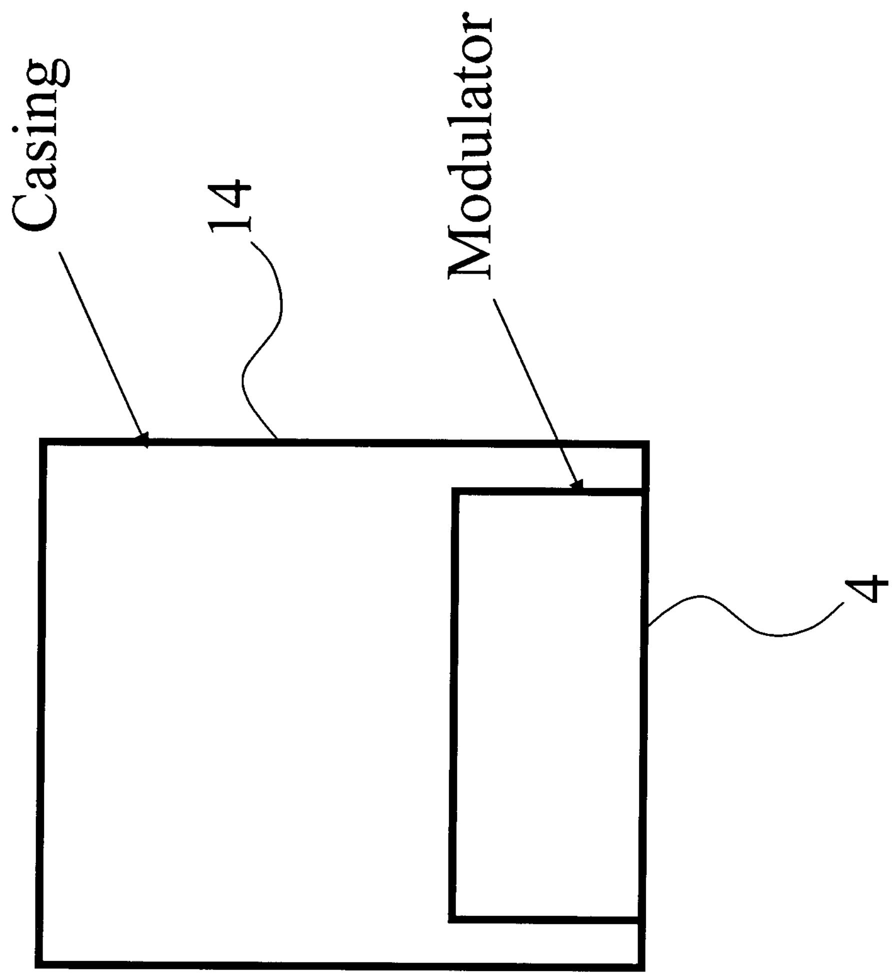

FIG. 11

OIPE JC32
SEP 1 5 2003
PATENT & TRADEMARK OFFICE

Atty. Dkt. No. 016790-0432

APPENDIX B

RECEIVED
SEP 22 2003
TECHNOLOGY CENTER 2800

EUGENE HECHT/ALFRED ZAJAC Adelphi University

OPTICS

ADDISON-WESLEY PUBLISHING COMPANY

READING, MASSACHUSETTS
MENLO PARK, CALIFORNIA · LONDON · AMSTERDAM · DON MILLS, ONTARIO · SYDNEY

The wave packet in the time domain, that is

$$E(t) = \begin{cases} E_0 \cos \omega_p t & \text{when } -T \le t \le T \\ 0 & \text{when } |t| > T \end{cases}$$

has the transform

$$A(\omega) = E_0 T \operatorname{sinc}(\omega_p - \omega)T, \tag{7.62}$$

where ω and k are related by the phase velocity. The frequency spectrum, except for the notational change from k to ω and L to T, is identical to that of Fig. 7.17(b). For the particular wave packet being studied the range of frequencies (ω or k) comprising the transform is certainly not finite. Yet if we were to speak of the *width* of the transform ($\Delta\omega$ or Δk), Fig. 7.17(b) rather suggests that we use $\Delta k = 2\pi/L$ or $\Delta\omega = 2\pi/T$. In contrast, the spatial or temporal extent of the pulse is quite unambiguous at $\Delta x = 2L$ or $\Delta t = 2T$, respectively. The product of the width of the packet in what might be called *k-space* and its width in *x-space* is $\Delta k\,\Delta x = 4\pi$ or analogously $\Delta\omega\,\Delta t = 4\pi$. One speaks of the quantities Δk and $\Delta\omega$ as the *frequency bandwidths*. Had we used a differently shaped pulse the bandwidth—pulse length product might certainly have been somewhat different. The ambiguity arises because we have not yet chosen one of the alternative possibilities for specifying $\Delta\omega$ and Δk. For example, rather than using the first minima of $A(k)$ (there are transforms which have no such minima, such as the Gaussian function of Section 11.2), we could have let Δk be the width of $A^2(k)$ at a point where the curve had dropped to $\frac{1}{2}$ or possibly $1/e$ of its maximum value. In any event, it will suffice for the time being to observe that

$$\Delta\nu \sim 1/\Delta t, \tag{7.63}$$

that is, the frequency bandwidth is of the order of magnitude of the reciprocal of the temporal extent of the pulse (Problem 7.20). If the wave packet has a narrow bandwidth, it will extend over a large region of space and time. Accordingly, a radio tuned to receive a bandwidth of $\Delta\nu$ will be capable of detecting pulses of duration no shorter than $\Delta t \sim 1/\Delta\nu$.

These considerations are of profound importance in quantum mechanics where wave packets describe particles and Eq. (7.63) is akin to the Heisenberg uncertainty principle.

7.10 OPTICAL BANDWIDTHS

Suppose that we examine the light emitted by what is loosely termed a monochromatic source, e.g. a sodium discharge lamp. When the beam is passed through some sort of spectrum analyzer we will be able to observe all of its various frequency components. Typically we would find that there were a number of fairly narrow frequency ranges which contained most of the energy and that these were separated by much larger regions of darkness. Each such brightly colored band is known as a *spectral line*. There are devices where the light enters by way of a slit and each line would actually be a colored image of that slit. Other analyzers will represent the frequency distribution on the screen of an oscilloscope. In any event, the individual spectral lines are never infinitely sharp. They always consist of a band of frequencies, however small (Fig. 7.18).

The electron transitions responsible for the generation of light have a duration of the order of 10^{-8} s. Because the emitted wave trains are finite there will be a spread in the frequencies present known as the *natural linewidth* [see Section 11.3.4(ii)]. Moreover, since the atoms are in random thermal motion the frequency spectrum will be altered by the Doppler effect. In addition, the atoms suffer collisions which interrupt the wave trains and again tend to broaden the frequency distribution. The total effect of all of these mechanisms is that each spectral line has a bandwidth $\Delta\nu$ rather than one single frequency. The time Δt which satisfies Eq. (7.63) is referred to as the *coherence time* and the length Δx given by

$$\Delta x = c\,\Delta t \tag{7.64}$$

is the *coherence length*.

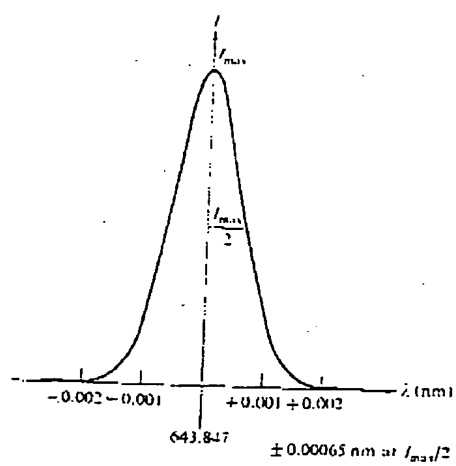

Fig. 7.18 The cadmium red ($\bar{\lambda}$ = 643.847 nm) spectral line from a low pressure lamp.

7.10

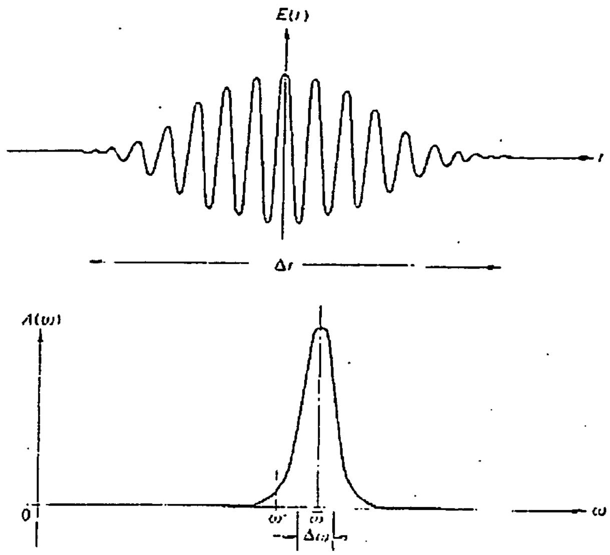

Fig. 7.19 A cosinusoidal wave train modulated by a Gaussian envelope along with its Gaussian transform.

Because of the quantized nature of the radiation process, light is emitted in the form of individual photons which for our present purposes can be represented by finite wave trains. Suppose that we have a quasimonochromatic thermal (nonlaser) light beam composed of N of these wave packets bearing a random phase relation to one another. The configuration of each wave packet, as drawn in Fig. 7.19, is assumed such that the square of its Fourier transform $A(\omega)$ resembles an irradiance versus frequency distribution often observed for spectral lines. Imagine then that we only look at one and the same harmonic frequency component in each packet, e.g. the one corresponding to ω'. Remember that each such component is an infinitely long, constant-amplitude wave. If every wave packet is assumed to be identical in form, the amplitude of the Fourier component associated with ω' will be the same for each. Since these have a random relative phase distribution it follows from Eq. (7.21) that the resultant will be a harmonic wave of frequency ω' having an amplitude proportional to $N^{\frac{1}{2}}$. The equivalent will be true, of course, for every frequency within the range constituting the wave packets. In other words, there is the same amount of energy present at each frequency in the composite wave as there is in the sum of the separate constituent wave trains at that frequency. As a result of the randomness of the wave trains, the individual harmonic components of the resultant wave will not have the same relative phases as they did in each packet. Thus the profile of the resultant will differ from that of the separate wave packets even though the amplitude of each frequency component present in the resultant is simply $N^{\frac{1}{2}}$ times its amplitude in any one packet. The observed spectral line corresponds to the power spectrum of the resultant beam, to be sure, but it also corresponds to the power spectrum of an individual packet. Ordinarily there will be a tremendous number of arbitrarily overlapping wave groups so that the envelope of the resultant will rarely, if ever, be zero. If the source is quasimonochromatic, i.e. if the bandwidth is small compared to the mean frequency $\bar{\nu}$, we can envision the resultant as being "almost" sinusoidal. In summary then, the composite wave can be pictured as in Fig. 7.20. We might imagine the frequency and amplitude to be randomly varying; the former over a range $\Delta\nu$ centered at $\bar{\nu}$. Accordingly, the *frequency stability* defined as $\Delta\nu/\bar{\nu}$ is a useful measure of spectral purity. Even a coherence time as short as 10^{-9} s corresponds to roughly a few million wavelengths of the rapidly oscillating carrier ($\bar{\nu}$) so that any amplitude or frequency variations will occur quite slowly in comparison. Equivalently we can introduce a time-varying phase factor such that the disturbance can be written as

$$E(t) = E_0(t)\cos[\varphi(t) - 2\pi\bar{\nu}t], \qquad (7.65)$$

where the separation between wave crests changes in time.

The average duration of a wave packet is Δt and so two points on the wave of Fig. 7.20 separated by more than Δt must lie on different contributing wave trains. These points would thus be completely uncorrelated in phase. In other words, if we determine the electric field of the composite wave as it passes by an idealized detector we could predict its phase fairly accurately for times much less than Δt later, but not at all for times greater than Δt. In Chapter 12 we will consider the *degree of coherence* which applies over the region between these extremes as well.

White light has a frequency range from 0.4×10^{15} Hz to about 0.7×10^{15} Hz, that is, a bandwidth of about 0.3×10^{15} Hz. The coherence time is then roughly 3×10^{-15} s which corresponds (7.64) to wave trains having a spatial extent only a few wavelengths long. *Accordingly, white light may be envisaged as a random succession of very short pulses.* Were we to synthesize white light, we would have to superimpose a broad continuous range of

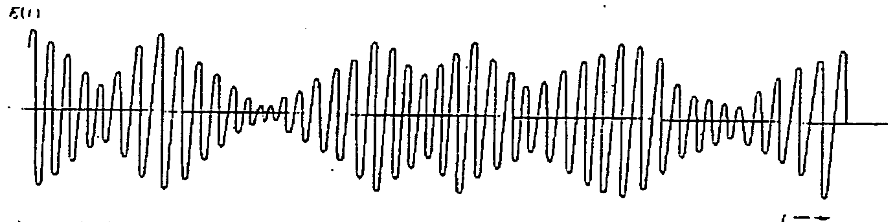

Fig. 7.20 A quasimonochromatic light wave.

harmonic constituents in order to produce the very short wave packets. Inversely, we can pass white light through a Fourier analyzer, such as a diffraction grating or a prism, and in so doing actually generate those components.

The available bandwidth in the visible spectrum (≈ 300 THz) is so broad that it represents something of a "wonderland" for the communications engineer. For example, a typical television channel occupies a range of 4 MHz in the electromagnetic spectrum ($\Delta\nu$ is determined by the duration of the pulses needed to control the scanning electron beam). Thus the visible region could carry roughly 75 million television channels. Needless to say this is an area of active research (see Section 8.11).

Ordinary discharge lamps have relatively large bandwidths leading to coherence lengths only of the order of several millimeters. In contrast, the spectral lines emitted by low-pressure isotope lamps such as Hg^{198} ($\lambda_{air} = 546.078$ nm) or the international standard Kr^{86} ($\lambda_{air} = 605.616$ nm) have bandwidths of roughly 1000 MHz. The corresponding coherence lengths are of the order of 1 m and coherence times are about 1 ns. The frequency stability is about one part per million—these sources are certainly quasimonochromatic.

By far the most spectacular of all present-day sources is the laser. Under optimum conditions, where temperature variations and vibrations were meticulously suppressed, a laser was actually operated at quite close to its theoretical limit of frequency constancy. A short-term frequency stability of about 8 parts per 10^{14} was attained* with a He—Ne continuous gas laser at $\lambda = 1153$ nm. That corresponds to a remarkably narrow bandwidth of about 20 Hz. More commonly, frequency stabilities of several parts per 10^9 are not very difficult to come by. There are commercially available CO_2 lasers which provide a short-term ($\sim 10^{-1}$ s) $\Delta\nu/\bar{\nu}$ ratio of 10^{-9} and a long-term ($\sim 10^{3}$ s) value of 10^{-8}.

* T. S. Jaseja, A. Javan, and C. H. Townes, "Frequency Stability of Helium–Neon Masers and Measurements of Length," *Phys. Rev. Letters* 10, 165 (1963).

PROBLEMS

7.1 Determine the resultant of the superposition of the parallel waves $E_1 = E_{01} \sin(\omega t + \varepsilon_1)$ and $E_2 = E_{02} \sin(\omega t + \varepsilon_2)$ when $\omega = 120\pi$, $E_{01} = 6$, $E_{02} = 8$, $\varepsilon_1 = 0$, and $\varepsilon_2 = \pi/2$. Plot each function and the resultant.

7.2* Show that the *optical path*, defined as the sum of the products of the various indices times the thicknesses of media traversed by a beam, that is, $\Sigma_i n_i x_i$, is equivalent to the length of the path in vacuum which would take the same time for that beam to negotiate.

7.3 a) How many wavelengths of $\lambda_0 = 500$ nm light will span a 1 m gap in vacuum?
b) How many waves span the gap when a 5 cm thick glass plate ($n = 1.5$) is inserted in the path?
c) Determine the O.P.D. between the two situations.
d) Verify that Λ/λ_0 corresponds to the difference between the solutions to (a) and (b) above.

7.4* Determine the optical path difference for the two waves *A* and *B* both having vacuum wavelengths of 500 nm depicted in Fig. 7.21; the glass ($n = 1.52$) tank is filled with water ($n = 1.33$). If the waves started out in phase and all of the above numbers are exact, find their relative phase difference at the finishing line.

7.5* Using Eqs. (7.9), (7.10), and (7.11) show that the resultant of the two waves

$$E_1 = E_{01} \sin[\omega t - k(x + \Delta x)]$$

and

$$E_2 = E_{01} \sin(\omega t - kx)$$